Workshop on ASTER and MODIS Data
for
Land Surface Studies

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USGS EROS Data Center
Sioux Falls, SD 57198

Laboratory Exercise

Using ASTER Data for Geologic Mapping in Semi-Arid Terrain

Introduction

Accurate geologic maps are a fundamental tool used by geologists for many research and practical endeavors. This certainly is true in the case of energy and mineral exploration. Yet, even now, at the beginning of the 21st century, there remain vast reaches of the earth's land surface for which there exists little or no geologic map coverage. This is even true for parts of the United States!

Moderate-resolution satellite land remotely sensed data have been used successfully over the past 30 years to provide geologists, including those exploring for non-renewable natural resources, with valuable geologic information that has been used to create regional to sub-regional geologic maps and has played a role in the discovery of new occurrences of oil, gold, copper, and other resources. As you have learned, ASTER data have characteristics that are particularly useful for geologic studies, especially where the rocks are well exposed.

In this exercise, you will assume the role of the exploration geologist whose job it is to produce a general geologic map and locate three ground targets where detailed field studies would be conducted as the next step in the exploration process. The exercise includes searching for, selecting, and ordering your data followed by digital data analysis and interpretation to generate a series of enhanced image products from which you will extract valuable information to produce a general geologic map and locate three areas for more detailed study.

Honing in on the Area

On a field trip to Nevada a while back, you ran into a grizzled old prospector in the bar one night who secretly told you of this "hot" area out in the desert northwest of Delta in west-central Utah that he called "Murd Mts." and which he wanted to stake claim to, but was down to his last dime. You opted not give him the grubstake he wanted, but you took his name and promised to give him a cut of anything you found out there. For that promise and bottle of top-shelf whisky, he whispered in your ear, "look around **thirty nine and a half north and a hundred and thirteen west**."

Selecting Your ASTER Data and Products

Using the EOS Data Gateway (EDG), locate, select, and "order" **one ASTER L1B scene** that you think will be best suited for meeting your needs, including being sure of finding yourself smack dab in the middle of the old prospector's Murd Mts. area

Next, given what you know about the ASTER higher-level standard data products, determine which of those products you think might be useful in mapping and assessing the mineral potential of the old prospector's area. Using the EDG's on-demand capabilities, "order" any **higher-level products** you think will be helpful to you. Use the L1B scene that you selected above as the input data set for the higher-level products.

Finally, check to see if there are any ASTER DEMs in the archive that cover most or all of the L1B scene that you ordered. If so, "order" **one DEM**, if you think it might be useful in your mapping and assessment of the old prospector's area.

Reducing the Size of the Area of Interest

Although the old prospector didn't exactly let on, the area that he is so high on actually is much small than ASTER scene you ordered. It turns out that the area of greatest interest is only about 275 square kilometers (~17 km by 16 km) in size. Consequently, to expedite your analysis and interpretation of the data, you will want to subset your ASTER L1B scene to cover just this 17 km x 16km area. However, before subsetting your data, you will want to resize the SWIR and TIR bands so they have the same number of pixels as the VNIR bands (4980 x 4200). Use ***Open Image File*** under **File** on the main ENVI menu to open your ASTER L1B image. Use the ***Resize Data*** function under **Basic Tools** to do that. Next, subset the three VNIR bands first by finding the pixel closest to **39º 39' 4.43" N, 113º 6' 9.68" W** in the VNIR bands and cutting out a spatial subset that is 1101 pixels (in the E-W direction) by 1151 pixels (in the N-S direction). Then, subset the same exact area in the SWIR and TIR bands. Finally, use the ***Save File As*** function under **File** to create a single 14-band ASTER image of the old prospectors Murd Mts. area.

Creating Enhanced Image Products for Interpretation

In this section of the exercise, you will use your newly created 14-band ASTER L1B image to generate a variety of enhanced image products of the primary area of interest. It is from these products that you will interpret most of the lithologic and structural geologic information from which you will create a general geologic map of the Murd Mts. area and select 3 smaller areas for further field-based studies.

Contrast-Enhanced, False-Color Composite. A contrast-enhanced false-color composite (FCC) is a good place to start your data analysis and interpretation process, because it will provide a good overview of the Murd Mts. area in a color scheme that is most familiar to you and closest to "natural" of any of the enhanced image products you will generate. Use ***Open Image File*** under **File** on the main ENVI menu to open your new 14-band subset ASTER L1B image. Display bands 3, 2, and 1 as (R), (G), and (B), respectively. Use ***Interactive Stretching*** under **Enhance** on the Image Display menu to contrast enhance your FCC image of the subset area of interest. When you are satisfied with the image appearance, save the image by using the ***Save Image As → Image File*** under **File** on the Image Display. Save the image as a jpeg file.

Band Ratio Images. Band ratio images can be used to enhance spectral variation of materials both by accentuating their spectral characteristics and by subduing topographic effects. With nine VNIR and SWIR bands there are 36 possible unique ratio combinations that could be produced, so this exercise expedites the process of selecting some optimum ratio combinations for you to work with. Using ***Band Ratios*** under **Transformations** on the main ENVI menu create the following 7 individual band rations 2/1 (accentuates iron oxide bearing rocks); 4/6,4/7, 4/8 (accentuates hydroxyl and/or carbonate bearing rocks); and 6/2, 7/2, and 8/2 (rather neutral with respect to OH^- and CO_3). Examine your individual ratio images for general impressions of light and dark areas and what the light areas, particularly, might represent. Produce between one and three color ratio composite images for interpretation by combining them in the following order R2/1 (R), R4/x(G), Rx/2(B). Tweek the contrast of the individual ratio images, if you wish, by using ***Interactive Stretching*** under **Enhance** on the Image Display menu. Save your color ratio composite image(s) as jpeg(s).

Decorrelation Stretch Images. Decorrelation stretch images have proven very useful for interpreting lithologic variation in areas where the rocks are well exposed, as they are in the Murd Mts. Decorrelation stretch images are calculated based on three input images selected by the analyst, and ENVI creates such images very quickly. Consequently, take 20-30 minutes and experiment with generating decorrelation stretch images that enhance the representation of the lithologic variations that exist in the Murd Mts. Use ***Decorrelation Stretch*** under **Transform** on the main ENVI menu. Produce and save (as jpgs) as many decorrelation stretch images as you think may be useful to your interpretation; however, among those you save include 4(R) 3(G) 7(B) and 10(R) 14(G) 11(B).

Principal Components Analysis. Over the years, principal components analysis probably is the data transform technique used more often by more analysts than any of the other data transform techniques. For geologic studies, it has proven useful as a tool for lithologic discrimination, and the 1st principal component, being essentially an albedo image, often displays important structural information. Use ***Principal Components*** under **Transform** on the main ENVI menu to create a 9-band principal components image from the VNIR and SWIR bands (bands 1-9) of your 14-band subset ASTER L1B image of the Murd Mts. Examine the individual principal component images and note the different information being reported in each PC image. No doubt, by now you have begun to formulate ideas about the geologic setting of the Murd Mts., so as you examine the individual component images look for patterns or other information that seem to support or challenge your emerging picture of

Murd Mts. geology. Next, based on your examination of the individual component images, create a few color PC images that your believe best portray the geology of the area. Save (as jpegs) as many of those images as you think will be useful to your interpretation; however, among those include PC 1(R) 2(G) 5(B). Next, following the same procedures, create and examine a 6-band PC image from the SWIR bands (bands 4-9) of your 14-band subset ASTER L1B image of the Murd Mts. Create and save any color PC images that you think may be useful to your interpretation, but be sure to include among those PC 1(R) 2(G) 3(B).

Interpreting Murd Mt. Enhanced Image Products

You have created a variety of enhanced image products, all of which contain different representations of and information about the geology of the Murd Mts. area. The objective of this part of the exercise is to extract from those enhanced images sufficient lithologic and structural geologic information to allow you to create a general geologic map of the Murd Mts. area. Spend a few minutes examining the FCC, band ratio, decorrelation stretch, and PC images (jpgs) that you created and saved during the last section of the exercise. Select one or two of each type to print as hard copies. Be sure to print all of your .jpg images at the same scale. Using the mylar overlay and pens provided, interpret the geology of the Murd Mts. area and create a general geologic map. Your final interpretation should contain, at a minimum, five distinct rock units…..although you may not be able to precisely identify the lithology of each unit. In addition, your interpretation should portray the general strike and dip of any sedimentary rock units you map, and it should show the location of one or more (there are many) faults. Finally, mark on your interpretation (map) the locations of three separate areas you might go to conduct follow-up field investigations, and be prepared to explain why you selected them.

Using the ASTER DEM of the Murd Mts.

As you are working on you geologic interpretation of the Murd Mts., you may find it useful (particularly to your structural geologic interpretation) to drape some or all of you enhanced image products over the topographic surface of the Murd Mts. as portrayed by the ASTER DEM. Load the enhanced image product (use the .img rather than the .jpg file) that you want to view in three dimensions into ENVI such that it appears in the **Available Bands List.** Then do the same with the ASTER DEM of the Murd Mts. Under **Topographic** on the main ENVI menu, select ***3D SurfaceView.*** If you have multiple enhanced images displayed, you must select the enhanced image product you want to drape on the topography. Next, select the ASTER DEM as the DEM input. Use 1200 and 2400 as the minimum and maximum elevations respectively. Note you can rotate and translate the 3D image to provide an unlimited number of view perspectives. You can also change the background color and vertical exaggeration.

ASTER Higher-Level Standard Data Products.

You can complete this exercise without using any of the ASTER higher-level standard data products, except for the DEM. However, if time permits, you may want to take a look at the various Level 2 ASTER standard data products that you “ordered” near the beginning of the exercise. Consider whether or not any of the Level 2 products would have been useful in completing the objectives of this exercise. Also, consider under what circumstances you would find these products most useful.

If time permits, perform some of the same activities included in this exercise using the atmospherically corrected surface radiance data of AST09 and AST09T. Try to assess if using the atmospherically corrected data would have provided more useful results than using the L1B data that you used for the exercise.